R-WD-12-3D

New Hampshire Volunteer Lake Assessment Program

2011
Merrimack Valley
Regional Report

Great Pond, Kingston, NH

NHDES
CELEBRATING 1987 25 YEARS 2012

R-WD-12-3D

New Hampshire Volunteer Lake Assessment Program 2011 Merrimack Valley Regional Report

State of New Hampshire
Department of Environmental Services
Water Division
Watershed Management Bureau
P.O. Box 95
29 Hazen Drive
Concord, NH 03302-0095

Thomas S. Burack
Commissioner

Harry T. Stewart
Water Division Direct

Ted Diers
Watershed Management Bureau Administrator

Prepared By:
Sara Steiner
VLAP Coordinator

May 2012

Table of Contents

List of Tables

List of Figures

Appendices

INTRODUCTION AND HISTORY

New Hampshire is home to approximately 900 lakes and ponds, and thousands of river miles. Protecting our lakes and rivers is critical to sustaining New Hampshire's drinking water resources, aquatic and natural environments, recreational and tourism industries.

The New Hampshire Department of Environmental Services (DES) recognizes the importance of these waterbodies in maintaining a healthy ecosystem for our current and future generations. Protecting high quality waters and restoring those that are impaired requires coordination and partnership between federal, state and local governments, non-profits, regional commissions, lake associations, and watershed residents.

To help citizens assess the health of New Hampshire's lakes and ponds, DES established the Volunteer Lake Assessment Program (VLAP) in 1985. The program is a volunteer-driven cooperative effort between the State and local governments, lake associations and lake residents. VLAP trains citizen volunteer monitors to collect water quality data at lakes and their associated tributaries on a monthly basis during the summer. VLAP compiles, interprets and reports the data back to state, federal and local governments, lake associations, and lake residents.

VLAP volunteer monitors are invaluable stewards for New Hampshire's lakes. Volunteer monitoring allows DES to establish a strong set of baseline chemical and biological data, determine long-term water quality trends and identify emerging water quality issues. DES acts on these findings through its funding and regulatory programs. Volunteers use this information to educate lake and watershed residents, businesses and local governments on best management practices to keep New Hampshire's lakes and ponds clean. They have been, and will continue to be, a key element in protecting the integrity of New Hampshire's lakes.

PROGRAM OVERVIEW

VLAP is a cooperative program between DES and lake residents and associations. Currently, approximately 500 volunteers monitor water quality at 180 lakes throughout New Hampshire. Interest in the program has grown drastically in the past ten years as citizens have become more aware of the connections between land use activities and water quality. Volunteer monitors continually collect high quality data on their local waterbodies and educate watershed residents.

Volunteer monitors are trained by DES to use monitoring equipment to collect lake water quality data, survey the surrounding watershed, and sample the streams and rivers that are tributaries to the lake. Each of the participating lakes must be visited by a DES biologist on a bi-annual basis. This visit is a valuable event in which the volunteer monitors have an opportunity to discuss water quality and watershed concerns and receive recommendations on potential remediation activities. Also, the event allows DES biologists to perform a field sampling techniques audit to evaluate volunteer monitor's ability to collect quality data, and to collect information on additional water quality parameters as necessary. Volunteers then sample on their own for the remaining summer months.

To further encourage volunteer monitoring, DES, established partnerships with the Lake Sunapee Protective Association (LSPA), Colby Sawyer College (CSC) in New London, NH, and Plymouth State University (PSU) in Plymouth, NH to operate VLAP satellite laboratories. These satellite laboratories serve as a convenient location for volunteers to borrow sampling equipment and deliver water samples for analysis. These strategic locations serve the Dartmouth Lake Sunapee, North Country and White Mountain regions.

The data gathered by the volunteers are reviewed by DES Quality Assurance Officers and Satellite Laboratory Managers and imported into DES' Environmental Monitoring Database (EMD). During the winter, DES biologists review and interpret the water quality data, perform trend analyses, and compile the results into annual reports. The high quality data gathered through VLAP also helps DES to conduct statewide surface water quality assessments. Assessment results and methodology are published and submitted to the Environmental Protection Agency (EPA) by DES every two years as a requirement of the Clean Water Act.

Once the volunteer monitors receive the data and the annual report for their lake, DES encourages the volunteers to relay that information to their respective associations, organizations, businesses, and local governments. Volunteers are also kept informed of the latest in lake management and water quality issues through an annual newsletter, technical and educational materials, regional workshops, and information on important legislation. In addition, DES biologists give presentations at lake association meetings and participate in youth education events. Educational initiatives, such as those mentioned above, allow volunteers to recognize potential water quality or shoreland violations around the lake and report their findings to DES. Volunteer monitors are dedicated, proactive lake stewards who are concerned for the well-being of their lakes.

MONITORING AND PARAMETER SUMMARY

VLAP encourages the collection of comprehensive data sets on key water quality parameters from participating lakes to determine overall health of the system. The lake and tributaries are sampled several times each year over a period of years. This establishes baseline water quality data and allows for the discernment of long-term water quality trends. These trends depict lake health and provide invaluable information to DES' mission to protect New Hampshire's lakes. The sampling efforts of the volunteer monitors supplement the environmental monitoring efforts of DES. Only through the assistance of volunteer monitors can such a high volume of sampling be accomplished throughout the state.

DES recognizes the importance of collecting data sets that are representative of varying conditions. VLAP has an EPA approved Quality Assurance Project Plan

(QAPP). The QAPP identifies specific responsibilities of DES and volunteers, sampling rationale, training procedures, and data management and quality control. DES and volunteers adhere to the QAPP regime to ensure high quality and representative data sets are collected.

Volunteers collect samples once per month in June, July and August, with some lakes monitored more or less frequently. Samples are collected at approximately the same location each month at each deep spot thermal layer, major tributaries (those flowing year round) and seasonal tributaries during spring run-off. The samples are analyzed for a variety of chemical and biological parameters including: pH, alkalinity, conductivity, chloride, turbidity, total phosphorus, and *E. coli* (optional). Additional in-lake data are also collected at the deep spot including lake transparency (with and without a viewscope), chlorophyll-a, phytoplankton, and dissolved oxygen and temperature profiles. Volunteer monitors are also trained to identify and collect samples of suspicious aquatic plants and cyanobacteria.

Environmental outcomes are measured by making comparisons to established New Hampshire averages and ranges of lake water quality, and state water quality standards. If analytical results for a particular sampling station frequently exceed state water quality averages or standards, then additional sampling to identify potential pollution sources is necessary. Volunteers often conduct storm event sampling, tributary bracket sampling, and spring run-off sampling to better assess watershed health and provide additional data to guide lake management decisions.

Appendix A includes a summary of each monitoring parameter and Appendix B includes recommended best management practices to remediate pollution sources.

MERRIMACK VALLEY REGIONAL SUMMARY

The Merrimack Valley Region (MV) consists of those towns in New Hampshire's Hillsborough County, western portions of Rockingham County, and southern portions of Merrimack County (Figure 1). This region is marked by the Merrimack River that runs right through the middle. It is home to some of New Hampshire's largest cities, Manchester, Nashua and Salem, and provides a variety of indoor and outdoor recreational activities.

Freshwater resources in the MV region provide valuable drinking water and recreational opportunities and play an important role in the regional economy. Freshwater recreation, including boating, fishing and swimming, in the MV Region generate approximately $44 million dollars in sales, $16 million in household income, and 704 jobs annually (Nordstrom, 2007). A perceived decline in water quality as measured by water clarity, levels, flows, aesthetic beauty, or overuse could result in approximately $19.5 million dollars in lost revenue, $7 million in lost household income and 306 lost jobs (Nordstrom, 2007).

Similarly, a decline in water clarity alone can result in a decrease in New Hampshire lakefront property values. A one meter decrease in water clarity can lead to an average decrease in property values of between 0.9% and 6.0% in New Hampshire (Gibbs, Halstead, Boyle& Huang, 2002). This may negatively impact property tax revenues, especially in a state where there are approximately 64,000 vacation homes concentrated around the Lakes Region (lakes), Seacoast (ocean) and North Country (skiing) (Loder, 2011). According to a 1999 publication of the Society for the

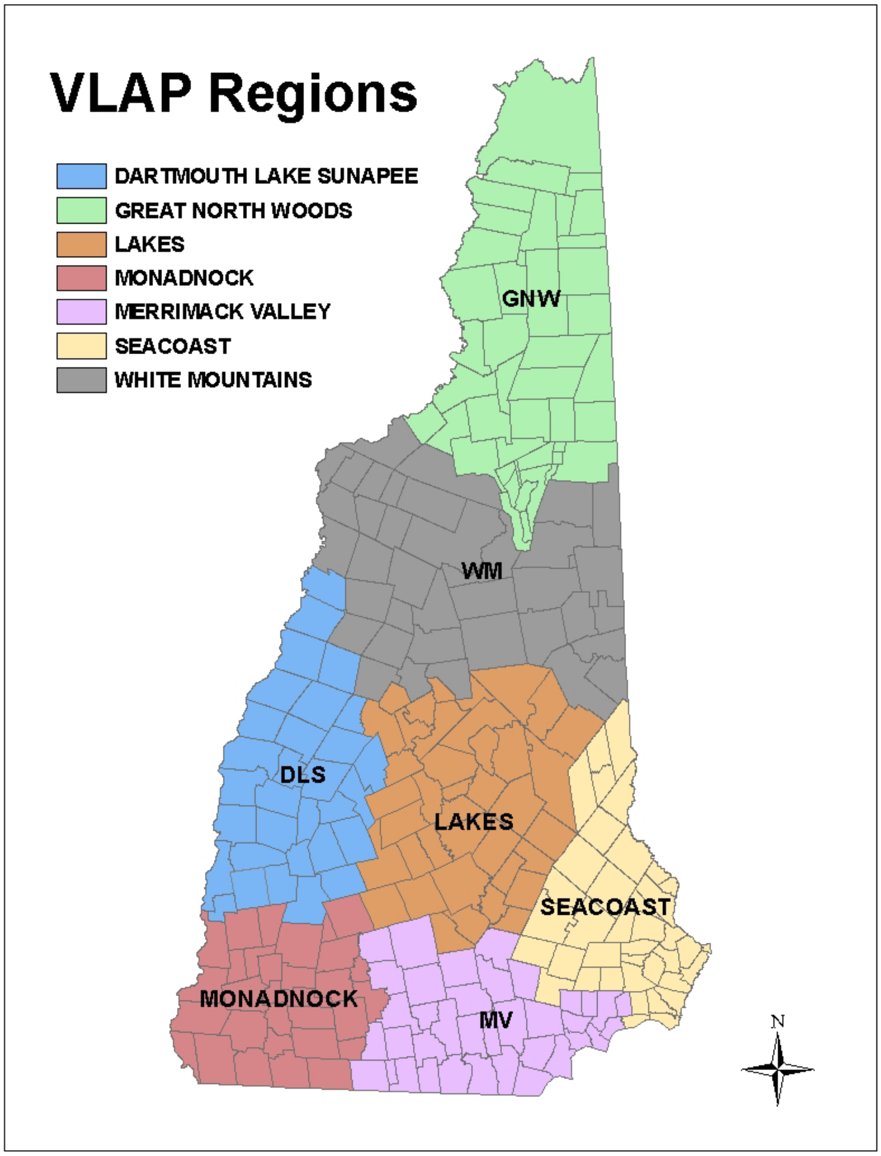


Figure 1. VLAP Regions

Protection of New Hampshire Forests, “The Economic Impact of Open Space in New Hampshire”, vacation homes contribute approximately $286 million to state and local tax revenues (note: open space includes lakes). For a town with a large number of lakefront homes (vacation or residential), a decline in water clarity can cause decreased property values and local tax revenue.

The MV region encompasses the Level 8 Hydrologic Unit Code (HUC) Watersheds of the Merrimack and Nashua Rivers. The HUC boundary defines a specific drainage basin of a major river or series of smaller rivers. There are 18 HUC 8 watersheds in New Hampshire. There are seven VLAP regions (Figure 1). VLAP lakes in the MV region include:

Lake Name	**Town**
Sebbins Pond	Bedford
Deering Lake	Deering
Beaver Lake	Derry
Big Island Pond	Derry
Pleasant Pond	Francestown
Scobie Pond (Haunted Lake)	Francestown
Angle Pond	Hampstead
Flints Pond	Hollis
Otternic Pond	Hudson
Robinson Pond	Hudson
Great Pond	Kingston
Crystal Lake	Manchester
Dorrs Pond	Manchester
Nutts Pond	Manchester
Pine Island Pond	Manchester
Stevens Pond	Manchester
Pratt Pond	New Ipswich
Country Pond	Newton
Long Pond	Pelham
Captains Pond	Salem
Phillips Pond	Sandown
Showell Pond	Sandown
Canobie Lake	Windham/Salem
Cobbetts Pond	Windham
Rock Pond	Windham

LAND USE AND POPULATION GROWTH

According to the 2010 update of the Society for the Protection of New Hampshire Forests' publication "New Hampshire's Changing Landscape 2010", New Hampshire's population is expected to increase by 180,000 through 2030 (Figure 2). Almost 70% of that growth will occur in the Southeastern part of the state, particularly in Merrimack, Hillsborough and Rockingham counties.

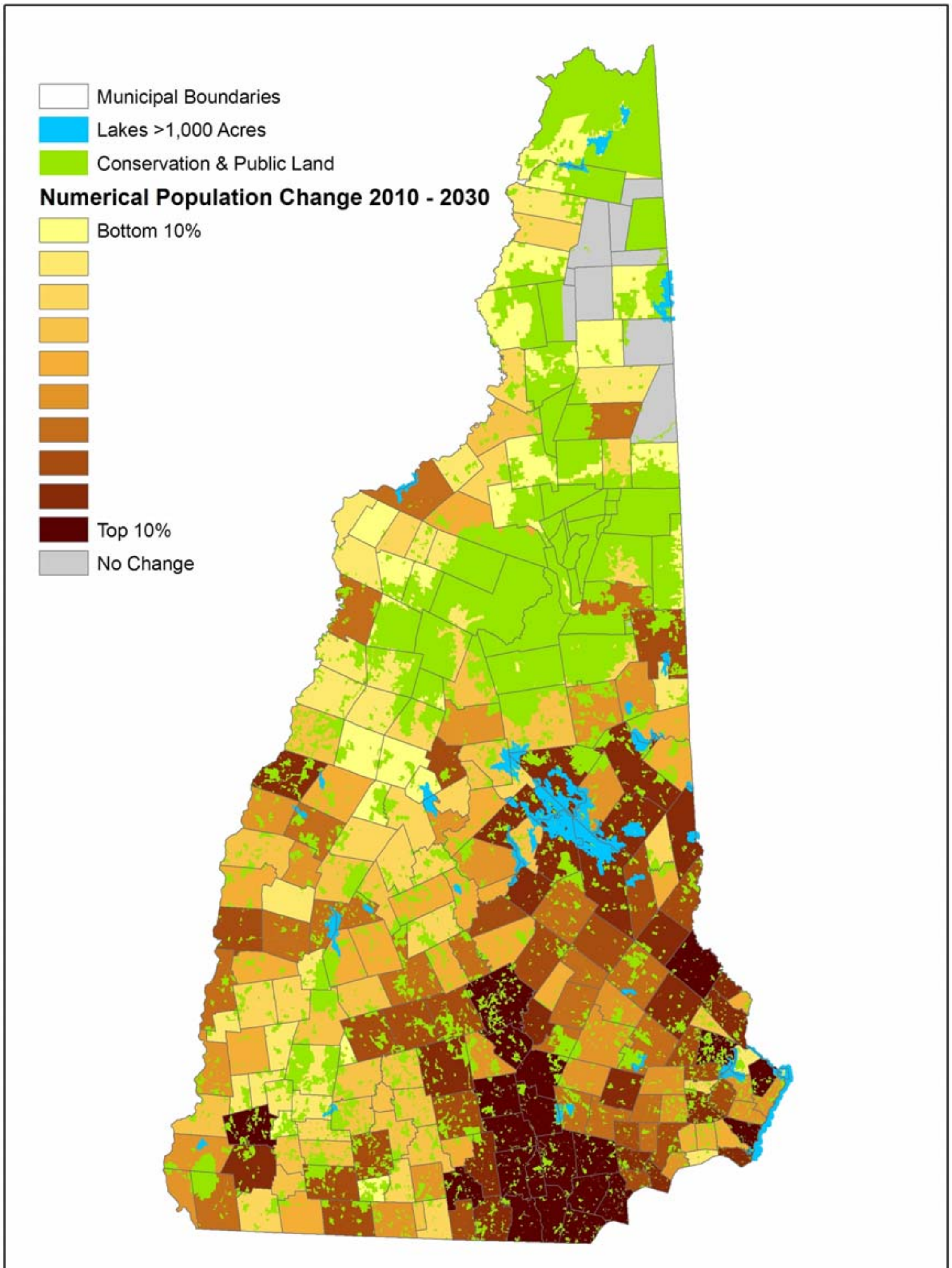
The population is anticipated to grow by approximately 115,000 people in Hillsborough, Rockingham and Merrimack counties by 2030. The majority of growth is estimated to follow main road corridors and urbanizing areas and is anticipated to be greatest in the towns of Goffstown, Manchester, Bedford, Merrimack, Litchfield, Nashua, Hudson, Pelham, Salem, Windham, Derry, and Londonderry.

The MV region is home to over 18,000 acres of water (lakes, river, and wetlands). Fifty-nine percent of this water is located in Hillsborough County, 37 percent is located in Rockingham County, and four percent is located in Merrimack County. Over 7,000 acres of water occurs in the towns predicted to experience the heaviest population growth in these three counties, comprising approximately 40 percent of the total waterbody acreage in the MV region.

Major land use categories in the MV region are agriculture, forest, wetland, residential, and the more urbanized areas of Manchester, Nashua and Salem. Population growth and land use change go hand in hand. Growing populations necessitate land clearing to accommodate new homes, housing complexes, roadways, and commercial businesses. Developed land corresponds to more impervious surfaces such as roadways, driveways, and rooftops. It also corresponds to the loss of tree canopy coverage, unstable sediments, wildlife habitat loss, and vegetative buffer loss. Consequences of development can negatively affect our waterbodies through increases in stormwater runoff, water temperatures, erosion, turbidity and nutrients, as well as shifts in aquatic life, aquatic plant, algae and cyanobacteria growth.

Overall, population growth in the MV region could greatly impact a large portion of its waterbodies. Efforts should be made to evaluate current land use activities, infrastructure, and regional water quality. This information should facilitate a plan to accommodate projected population growth while conserving and protecting valuable land and water resources.

Figure 2. NH Population Growth per Town 2010-2030



EXOTIC SPECIES

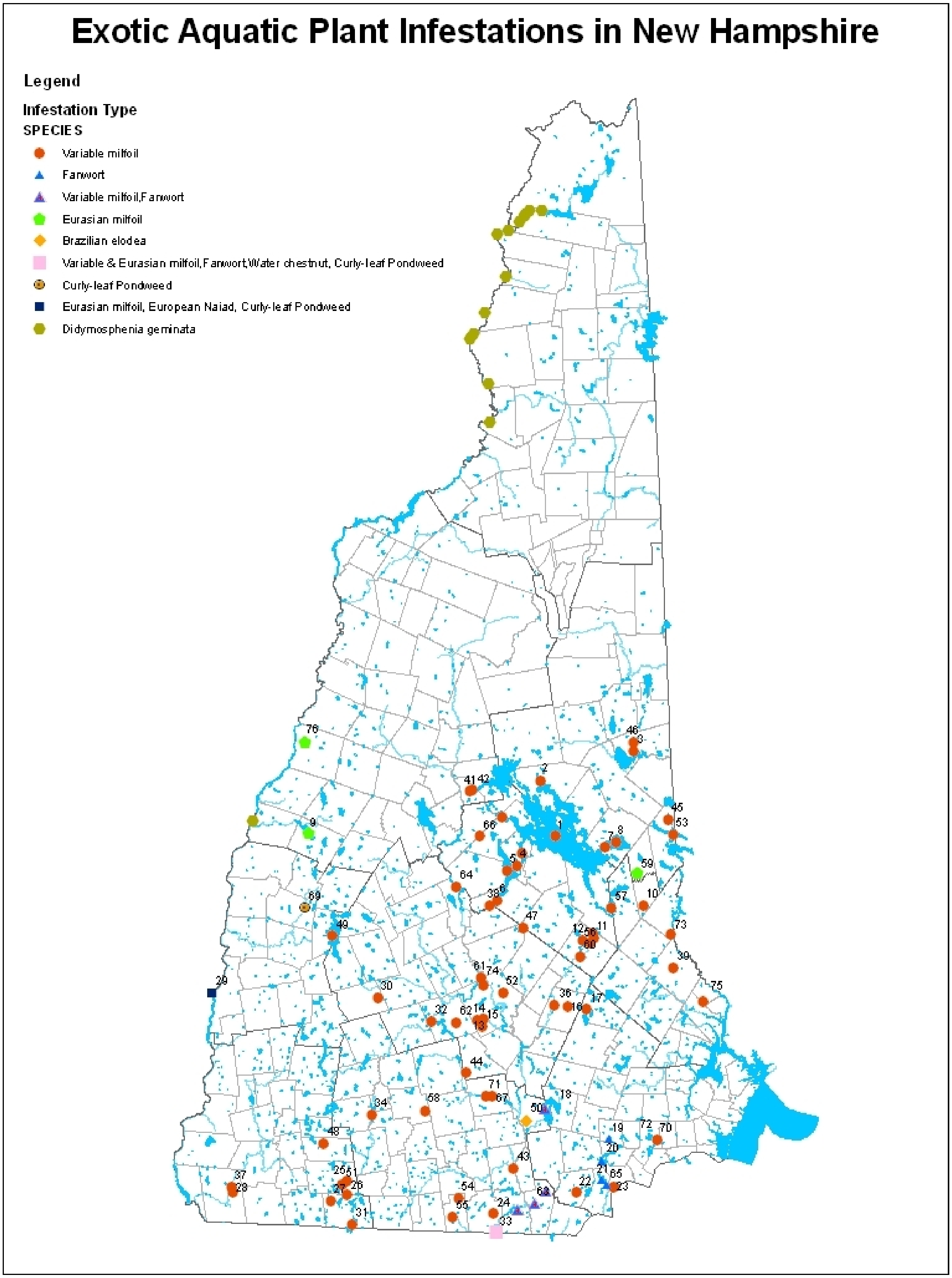
Exotic aquatic species are those plants and animals not native to New Hampshire's waterbodies, such as Variable milfoil and Zebra mussels. Many of these species are invasive and quickly spread throughout the aquatic system, altering habitat and the ecology of the system, often to the detriment of native species. They are a serious threat to the health of New Hampshire's aquatic ecosystem, recreation and tourism industries.

New Hampshire has 85 exotic plant infestations in 76 waterbodies. Those include Variable milfoil, Eurasian milfoil, Brazilian Elodea, Water Chestnut, Curly-leaf Pondweed, Fanwort, European Naiad, and Didymo ("Rock Snot"). Variable milfoil inhabits the majority of infested waterbodies, and Didymo, an invasive alga, has now infested 54 river miles in the North Country. Currently, 21 waterbodies in the MV region are infested with an exotic species. Eighteen waterbodies are infested with Variable milfoil, nine are infested with Fanwort, the Nashua River also has Water chestnut and Curly-leaf Pondweed infestations, and Nutts Pond is infested with Brazilian elodea. Many waterbodies have multiple infestations including Massabesic Lake, Mine Falls Pond, Nashua River, Big Island Pond, Otternic Pond, and Robinson Pond. The MV region experiences a range of exotics species that are rare elsewhere in New Hampshire.

The unique nature and invasive tendencies of these exotic species heighten the need to prevent new infestations, manage current infestations and engage watershed residents. One program that educates the public and engages watershed residents is the DES Weed Watchers Program. The Weed Watchers program has approximately 750 volunteers dedicated to monitoring lakes and ponds for the presence of exotic aquatic plants. Volunteers are trained to survey their lake or pond once a month from May through September. To survey, volunteers slowly boat, or sometimes snorkel, around the perimeter of the waterbody and its islands. Using the materials provided in the Weed Watcher kit, volunteers look for suspicious aquatic plant species. After a trip or two around the waterbody, volunteers have a good knowledge of its plant community and immediately notice even the most subtle change. If a suspicious plant is found, the volunteers send a specimen to DES for identification, either in the form of a live specimen mailed to DES, or as a photograph emailed to the Exotic Species Program Coordinator. Upon positive identification, a biologist visits the site to determine the extent of infestation, initiates a rapid response management technique where possible, and formulates a long-term management plan to control the nuisance infestation.

Another program dedicated to public education and engaging watershed residents is the Lake Host™ program. The Lake Host™ Program is funded through DES and Federal grants. The program was developed in 2002 by NH LAKES and DES to educate and prevent boaters from spreading exotic aquatic plants to waterbodies in New Hampshire. Since then, the number of participating waterbodies has doubled, the number of volunteers involved and boats inspected has quadrupled, and the number of "saves" (exotic plants discovered) has consistently increased. The program is invaluable in educating boaters, preventing recreational hazards, avoiding property value and aquatic ecosystem decline, addressing aesthetic issues, and saving costly remediation efforts.

Figure 3. NH Exotic Aquatic Plant Infestations



GEOMORPHOLOGY AND CLIMATE

Chemical, physical and biological properties of lakes often reflect how they were formed. Lake formation can occur in a variety of ways. In New Hampshire, most lakes were formed during the last ice age as glaciers retreated. Lakes were also formed from rivers (oxbow), and were man and animal made (impoundments, dams and beavers). These formations create distinct lake morphology, such as length, width, area and volume that affect the lake's ability to adapt to shifts in climate and land use.

Along with morphological characteristics of lakes, the bedrock and sediment geology is also important in understanding lake properties. Underlying geological properties can affect the pH and acid neutralizing capacity (ANC) of our surface and groundwater. New Hampshire is typically referred to as the "Granite State" because the bedrock geology consists of variations of Igneous Rock high in granite content and typically contributes to a lower pH and less capacity to buffer acidic inputs such as acid rain. Metamorphic rocks make up the remainder of bedrock geology and consist of slate, schist, quartzite and carbonate rocks which tend to contribute to a more neutral pH and better buffering capacity.

Along with bedrock geology, climate also drives multiple processes in lake systems. Lakes respond to shifting weather conditions such as sunlight, rainfall, air temperature, and wind and wave action in various ways. This variability is reflected in the types and number of biological communities present, and chemical and physical properties of the lake system. It is essential that we understand how these factors influence water quality data collected at individual lake systems. Therefore, volunteers record pertinent weather data, rain and storm event totals on field data sheets while sampling.

To summarize MV region climate conditions in 2011, the air temperatures were warm, the water slightly cooler, and May and July rainfall amounts were below average based on air and rainfall data recorded in Manchester, NH and surface water temperatures recorded by VLAP (Table 1). Average air temperatures in May, July, August, and September were warmer than historical averages, while June was slightly below average. Overall, the 2011 average summer air temperature was 2.1° warmer than the historical average. Surface water temperatures were below average in June and August, but spiked to almost 80° in July during the hot, dry spell, however the average summer surface water temperature was 0.6° below normal.

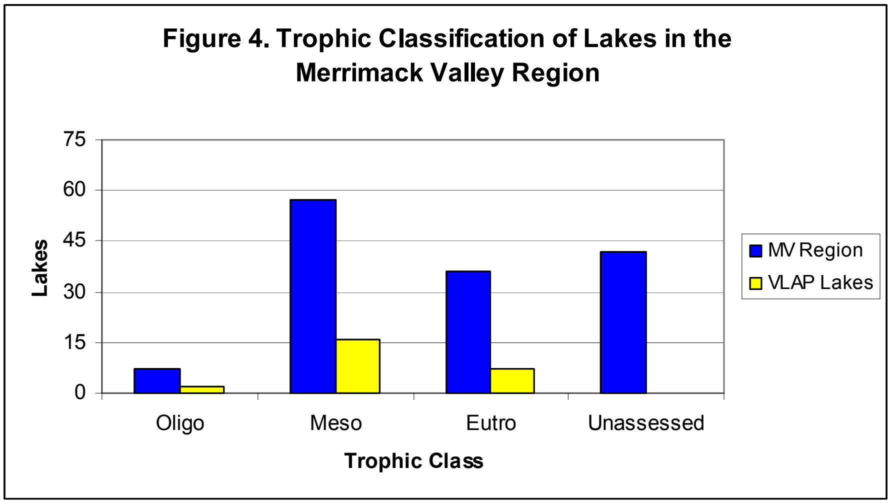
Table 1. Current Year and Historical Average Temperature and Precipitation Data for MV Region

	May	June	July	August	September	Summer
2011 Average Air Temperature (°F)	59.7	66.5	75.3	72.1	65.8	67.9
Annual Average Air Temperature (°F)	58.0	67.0	72.0	70.0	62.0	65.8
2011 Average Surface Water Temperature (°F)	-------	70.2	79.3	74.3	--------	74.6
Annual Average Surface Water Temperature (°F)	-------	72.8	76.9	75.8	--------	75.2
2011 Precipitation (in.)	3.09	4.53	1.47	7.23	5.81	4.43
Annual Average (in.)	3.82	4.11	3.79	3.67	3.39	3.76

The 2011 monthly summer rainfall amounts were well above average in June, August and September. The end of the summer season was marked by Tropical Storm Irene, which dumped over 3.5 inches of rain in 24 hours. Tropical Storm Irene also caused severe flooding and damage in the northern and western portions of New Hampshire. The above average rainfall likely let to an increase in lake turbidity, decrease in water clarity, and an increase in phosphorus and algal growth.

MONITORING AND ASSESSMENT

New Hampshire considers a public water to be a great pond or artificial impoundment greater than 10 acres in size, rivers, streams and tidal waters. The MV region consists of 142 lakes, or great ponds, and 25 of those lakes participate in VLAP. Data on the remaining 80 percent of lakes are sparse, being only occasionally sampled through the DES Lake Survey Program.



The DES Lake Survey Program monitors NH's lakes on a rotating basis, with the goal of conducting a comprehensive lake survey every 10 to 15 years. The surveys compile chemical, biological and morphological data. The data are used to assign a lake trophic class to each waterbody. The trophic class provides an assessment on how "aged" a lake is and can provide information on how population growth and human activities may be accelerating the aging process, also know as lake eutrophication.

Three trophic classes are used to assess a lake's overall health, Oligotrophic, Mesotrophic and Eutrophic. Oligotrophic lakes have high dissolved oxygen levels (> 5 mg/L), high transparency (> 12 ft.), low chlorophyll-a concentrations (< 4 mg/L), low phosphorus concentrations (< 10 ug/L), and sparse aquatic plant growth. Eutrophic lakes have low levels of dissolved oxygen (< 2 mg/L), low transparency (< 6 ft.), high chlorophyll-a concentrations (> 15 mg/L), high phosphorus concentrations (> 20 ug/L), and abundant aquatic plant growth. Mesotrophic lakes have characteristics that fall in between those of Oligotrophic and Eutrophic lakes for the parameters listed.

The trophic class breakdown of the MV region lakes is shown in Figure 4. Seven lakes are Oligtrophic, 57 Mesotrophic, 36 Eutrophic, and 42 are un-assessed for trophic classification due to lack of data. Two Oligotrophic, 16 Mesotrophic, and seven Eutrophic lakes participate in VLAP. Approximately 65 percent of the MV lakes are classified as Mesotrophic and Eutrophic; and only 5 percent are considered Oligotrophic. The MV region experiences large developmental pressures and as human activities accelerates lake aging, it is imperative to keep a close eye on the health of those lakes in the Oligotrophic and Mesotrophic classes. Efforts should also be made to gather data on the un-assessed waterbodies. Protecting a lake and preventing lake aging is much more cost-effective than restoring a damaged lake.

VLAP Water Quality Data Interpretation

The MV region is home to 25 lakes and ponds that participate in VLAP. Volunteer monitors at each lake collect comprehensive data sets at the deepest spot of the lake and from streams entering or exiting the lake. Deep spot sample collection is representative of overall lake quality and provides insight into how the lake responds to localized events such as stormwater and drought. Deep spot data are used to establish long term water quality trends and to provide information into the overall health of the waterbody. Stream sample collection is representative of what flows into the lake from the surrounding watershed. Stream data are used to identify potential watershed pollution problems so that remediation actions occur before they negatively impact the overall health of the waterbody.

The following section provides a summary of the VLAP monitoring parameters, long-term water quality trends, and an analysis of the current year and historical data for the VLAP lakes and ponds in the MV region compared with regional and state medians. The deep spot data for the epilimnion, or surface water layer, is compared to the New Hampshire median to provide an understanding of how the quality of your lake deep spot compares to other New Hampshire lake deep spots. Similarly, the epilimnion data are compared to the regional median to provide an understanding of how the quality of your lake deep spot compares with other local lakes. Median values were utilized to represent historical state and regional conditions as the value tends to better represent the actual middle number while minimizing the effects of outlier values. Average annual lake and regional values are then compared to the historical medians.

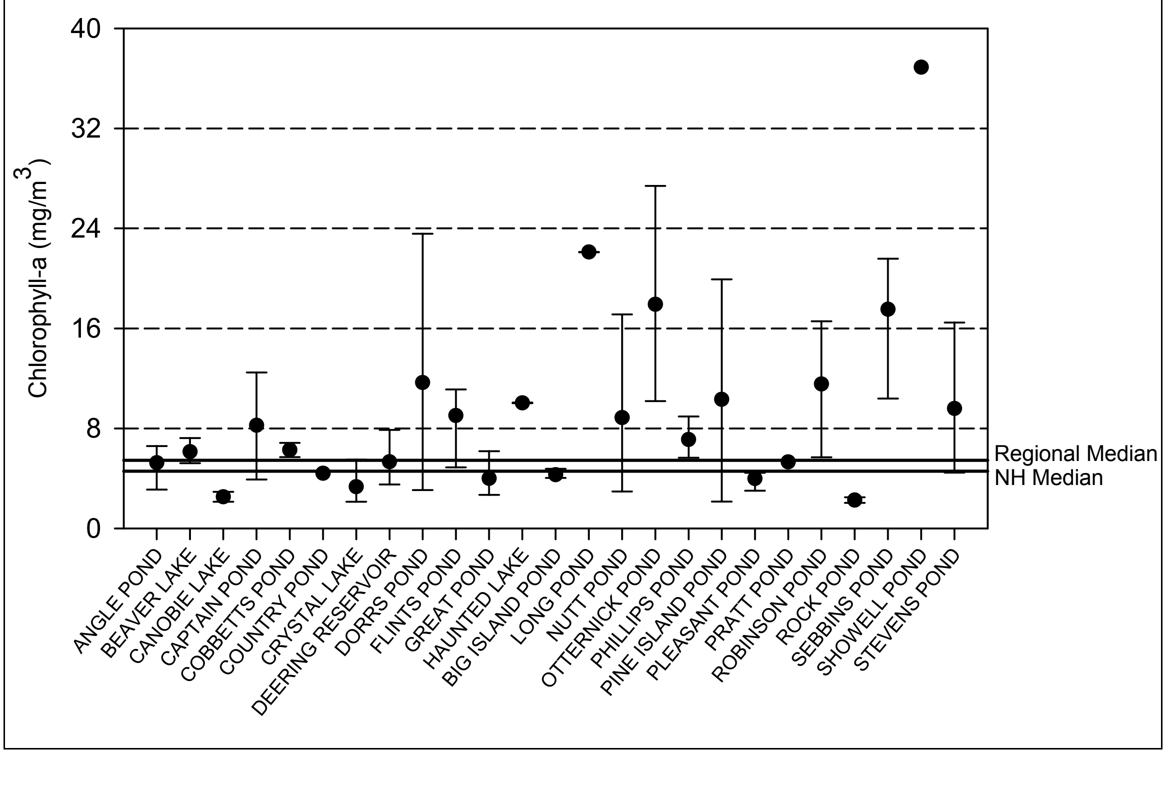
A complete list of monitoring parameters and how to interpret data are included in Appendix A.

Annual and Historical Chlorophyll-a Results

Algae are microscopic plants that are naturally found in the lake ecosystem. Algae and cyanobacteria contain chlorophyll-a, a pigment used for photosynthesis. The measurement of chlorophyll-a in the water gives biologists an estimation of the algal abundance or lake productivity. **The median summer chlorophyll-a concentration for New Hampshire's lakes and ponds is 4.58 mg/m3. The median chlorophyll-a concentration for the MV region is 5.45 mg/m³.**

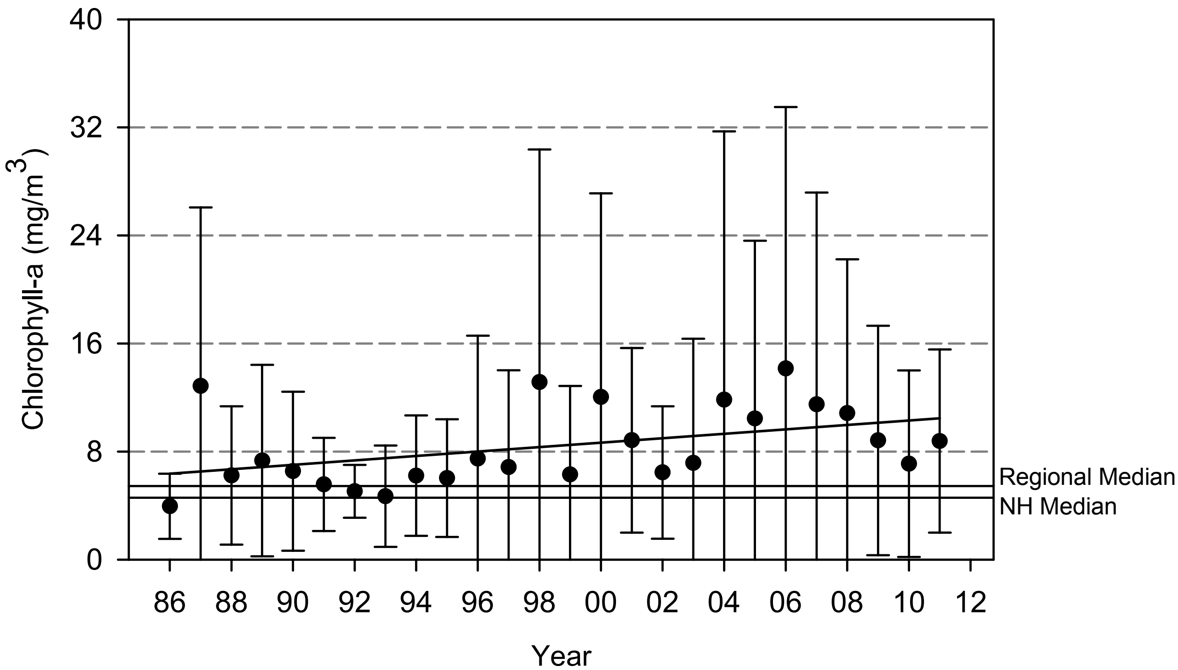
The 2011 average chlorophyll-a concentrations for each lake in the MV region are represented in Figure 5. The regional and state medians are provided for reference. The average chlorophyll-a concentrations at seven MV lake deep spot stations are equal to or below the state median and are typically representative of good water quality. Five lakes experienced average chlorophyll-a concentrations equal to or slightly greater than the regional median and are more representative of average water quality. Thirteen lakes experienced average chlorophyll-a concentrations much greater than the state and regional medians and are representative of poor water quality. Specifically, these lakes experienced chlorophylla-a concentrations indicative of algal or cyanobacteria blooms at some point during 2011. Four of these lakes are located in the urban environment of Manchester and are greatly impacted by stormwater runoff from impervious surfaces and I 93, and six lakes have experienced widespread cyanobacteria problems in recent years. Approximately 70 percent of the sampled deep spots have chlorophyll-a concentrations representative of Mesotrophic and Eutrophic classifications.

Figure 5. 2011 Average Chlorophyll-a Concentration for MV Lakes



The average annual chlorophyll-a concentrations for the MV region are represented in Figure 6. Average chlorophyll-a concentrations for the region generally remained between 5.0 and 8.0 mg/m^3 from 1986 through 1997. Since then, chlorophyll-a concentrations have almost doubled to between 10.0 and 16.0 mg/m^3. Part of this can be attributed to the urban ponds of Manchester joining the program in 2000, however, other regional lakes have also experienced increased chlorophyll-a and cyanobacteria problems during this period. Visual observation of the trend line indicates regional chlorophyll-a concentrations, and therefore algal growth, are increasing over time.

Figure 6. MV Region Average Annual Chlorophyll-a Concentration



Chlorophyll-a Trend Analysis

MV region lakes with 10 or more consecutive years of data were subject to statistical analyses to determine whether water quality trends were significantly improving, degrading, stable, or variable, meaning values fluctuate between years and there is no clear trend. Chlorophyll-a trends were assessed for approximately 20 deep spots at 18 lakes in the region. Seven lakes did not have 10 or more consecutive years of data, therefore, trend analyses were not conducted. Approximately 70 percent of MV lakes have 10 or more years of consecutive data collection on record.

Table 2 represents the MV lake chlorophyll-a trends with the direction of the arrow indicating whether chlorophyll increased, decreased, or remained stable. Note that improving trends reflect a decrease in chlorophyll levels, and vice-versa. Approximately 60 percent of lake deep spots in the region have a stable or variable chlorophyll-a trend, meaning the chlorophyll-a concentrations have not significantly increased or decreased. Twenty-five percent of lake deep spots have degrading chlorophyll-a trends, meaning chlorophyll-a concentrations have significantly increased. Ten percent of lake deep spots have an improving trend, meaning chlorophyll-a concentrations have significantly decreased. Chlorophyll-a concentrations are typically related to phosphorus concentrations because as phosphorus increases, more algal growth occurs. The stable and improving chlorophyll-a trends are a positive sign for the region, however the degrading trends are concerning and indicate the necessity for watershed management activities to reduce phosphorus loading.

Table 2. Chlorophyll-a Trends in MV Lakes

Lake Name	Improve	Degrade	Stable	Variable
Canobie Lake	▼			
Nutts Pond	▼			
Cobbetts Pond (2 deep spots)		▲		
Great Pond, South		▲		
Big Island Pond		▲		
Pratt Pond		▲		
Beaver Lake			►◄	
Deering Lake			►◄	
Dorrs Pond			►◄	
Great Pond, North			►◄	
Robinson Pond			►◄	
Captains Pond				✶
Crystal Lake				✶
Pine Island Pond				✶
Pleasant Pond				✶
Rock Pond				✶
Scobie Pond (Haunted Lake)				✶
Sebbins Pond				✶
Stevens Pond				✶

Annual and Historical Transparency Results

Volunteer monitors use the Secchi disk, a 20 cm disk with alternating black and white quadrants, to measure how far a person can see into the water. Transparency, a measure of water clarity, can be affected by algae and sediment in the water, as well as the natural color of the water. Transparency may also be measured using a viewscope, a cylindrical tube, designed to decrease surface water properties that may cause difficulty in viewing the Secchi disk. A comparison of transparency readings collected with and without the use of a viewscope shows that the viewscope typically increases the depth to which the Secchi disk can be seen into the lake, particularly on sunny and windy days. **The median summer transparency for New Hampshire's lakes and ponds is 3.20 meters. The median transparency for the MV region is 3.00 meters.**

The MV Region experienced above average rainfall during the 2011 sampling season, and was marked by Tropical Storm Irene at the end of August. This likely resulted in a lower average transparency for many of the region's waterbodies as stormwater runoff transports exposed and unstable sediments and debris.

Figure 7 represents the 2011 average transparency for each lake in the MV Region compared with state and regional medians. The average transparencies at 14 MV lake deep spots are below both the state and regional medians, and eight of those are below 2.0 meters which is typically representative of poor water quality conditions. Two lakes fall between the regional and state median, and 11 are above the state and regional medians and are typically representative of good water quality. Lake depth plays an important role when interpreting transparency data. Shallow lakes will typically report lower transparencies than deeper lakes, yet these waterbodies may be quite clear. A better representation would be to look at how transparency changes over time.

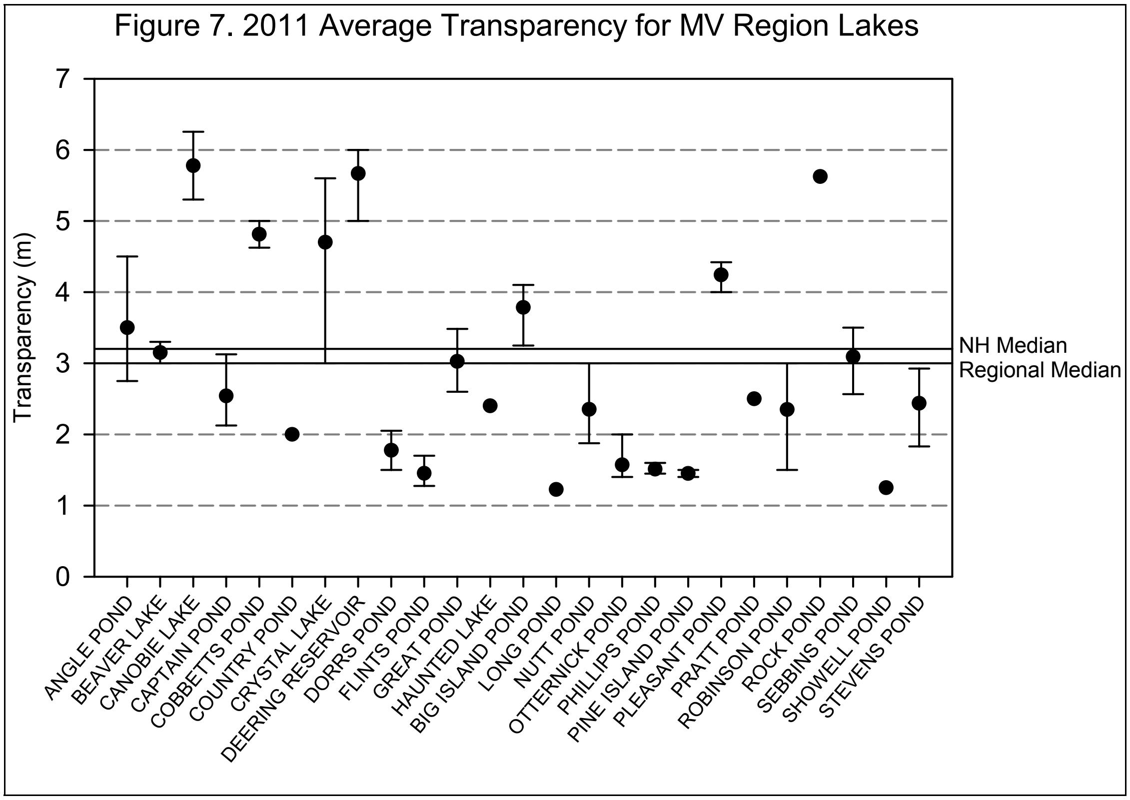
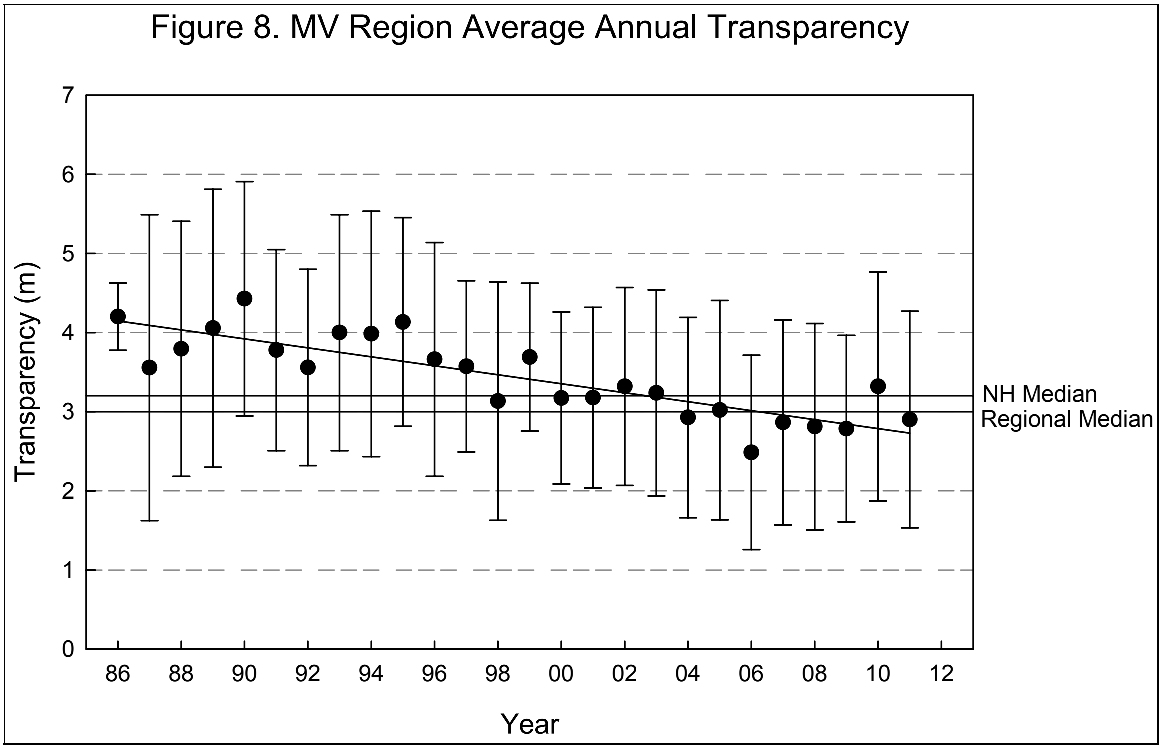


Figure 7. 2011 Average Transparency for MV Region Lakes
Transparency (m)
0
1
2
3
4
5
6
7
NH Median
Regional Median
ANGLE POND
BEAVER LAKE
CANOBIE LAKE
CAPTAIN POND
COBBETTS POND
COUNTRY POND
CRYSTAL LAKE
DEERING RESERVOIR
DORRS POND
FLINTS POND
GREAT POND
HAUNTED LAKE
BIG ISLAND POND
LONG POND
NUTT POND
OTTERNICK POND
PHILLIPS POND
PINE ISLAND POND
PLEASANT POND
PRATT POND
ROBINSON POND
ROCK POND
SEBBINS POND
SHOWELL POND
STEVENS POND

Figure 8 represents the average annual transparency for the MV region. Average transparencies for the region remained at or above the regional and state medians until 2004, where they have consistently remained below the regional median. Regional transparency has degraded by approximately 1.0 meter (3 ft.) over the span of 25 years. This degradation appears to correlate with the increase in regional chlorophyll-a concentrations (Figure 6).



Transparency Trend Analyses

MV Region lakes with 10 or more consecutive years of data were subject to statistical analyses to determine whether water quality trends were significantly improving, degrading, stable, or variable, meaning values fluctuate between years and there is no clear trend. Transparency trends were assessed for 20 deep spots at 18 lakes in the region. Approximately 70 percent of the MV lakes have 10 or more years of consecutive data collection.

Table 3 represents the MV lake transparency trends with the direction of the arrow indicating whether the transparency increased, decreased, or remained stable. Note that improving trends reflect an increase in transparency, and vice-versa. Fifty percent of lake deep spots have a stable transparency trend, meaning the transparency has not significantly improved or degraded. Approximately 30 percent of the lake deep spots have a degrading trend, meaning transparency has worsened (decreased) over time. And only one lake has an improving transparency trend, meaning transparency has improved (increased) over time.

Transparency, or water clarity, is typically affected by the amount of algae, color, and particulate matter within the water column. The stable transparency trends for the region are a positive sign; however transparency at 30 percent of the lake deep spots is degrading, or getting worse, and 25 percent of lakes are experiencing a degrading or increasing, chlorophyll-a concentration (Table 2) which can explain the corresponding decline in transparency.

Stormwater runoff transports nutrients responsible for algal and plant growth to a lake. It is imperative to identify potential nutrient sources in the watershed and utilize best management practices to control stormwater runoff. Please refer to Appendix B for reference material on do-it-yourself stormwater best management practices.

Table 3. Transparency Trends in MV Lakes

Lake Name	Improve	Degrade	Stable	Variable
Rock Pond	▲			
Beaver Lake		▼		
Big Island Pond		▼		
Cobbetts Pond (2 stations)		▼		
Pratt Pond		▼		
Robinson Pond		▼		
Canobie Lake			►◄	
Captains Pond			►◄	
Crystal Lake			►◄	
Deering Lake			►◄	
Dorrs Pond			►◄	
Great Pond (2 stations)			►◄	
Nutts Pond			►◄	
Pine Island Pond			►◄	
Pleasant Pond			►◄	
Stevens Pond			►◄	
Scobie Pond (Haunted Lake)				✶
Sebbins Pond				✶

Annual and Historical Total Phosphorus Results

Phosphorus is typically the limiting nutrient for vascular plant and algal growth in New Hampshire's lakes and ponds. Excessive phosphorus in a pond can lead to increased plant and algal growth over time. **The median summer epilimnetic (upper layer) total phosphorus concentration of New Hampshire's lakes and ponds is 12 ug/L. The median epilimnetic total phosphorus concentration of the MV Region is 13 ug/L.**

Figure 9 represents the 2011 average epilimnetic total phosphorus concentration for MV region lakes. The regional and state medians are provided as reference. Ten MV lakes experienced average phosphorus concentrations equal to or below the regional and state medians and are representative of Oligotrophic/Mesotrophic conditions. Fifteen MV lakes experienced average phosphorus concentrations above the regional and state medians and are representative of Mesotrophic/Eutrophic conditions. Total phosphorus concentrations, particularly above 20 ug/L, contribute to excess algal and cyanobacteria growth. Watershed management efforts should address excess phosphorus loading, particularly at these lakes.

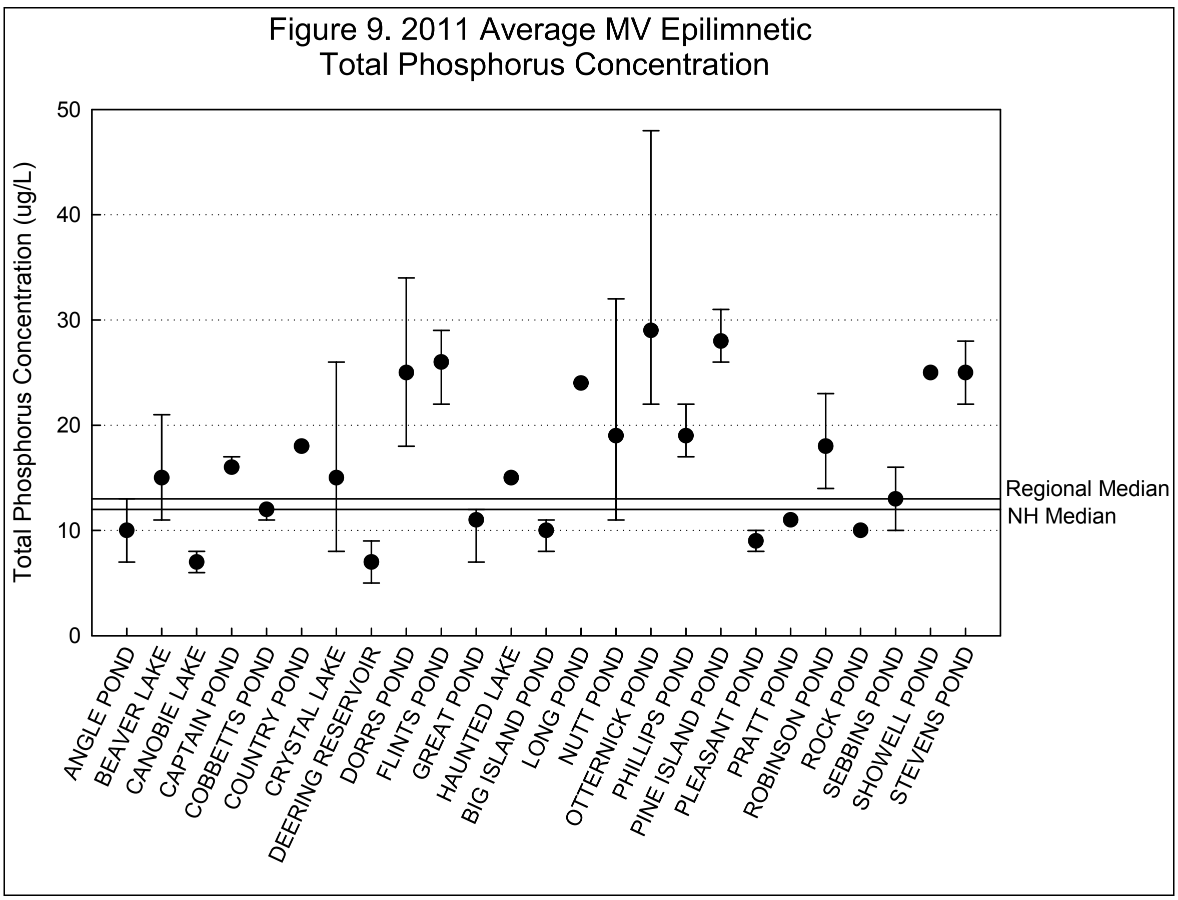
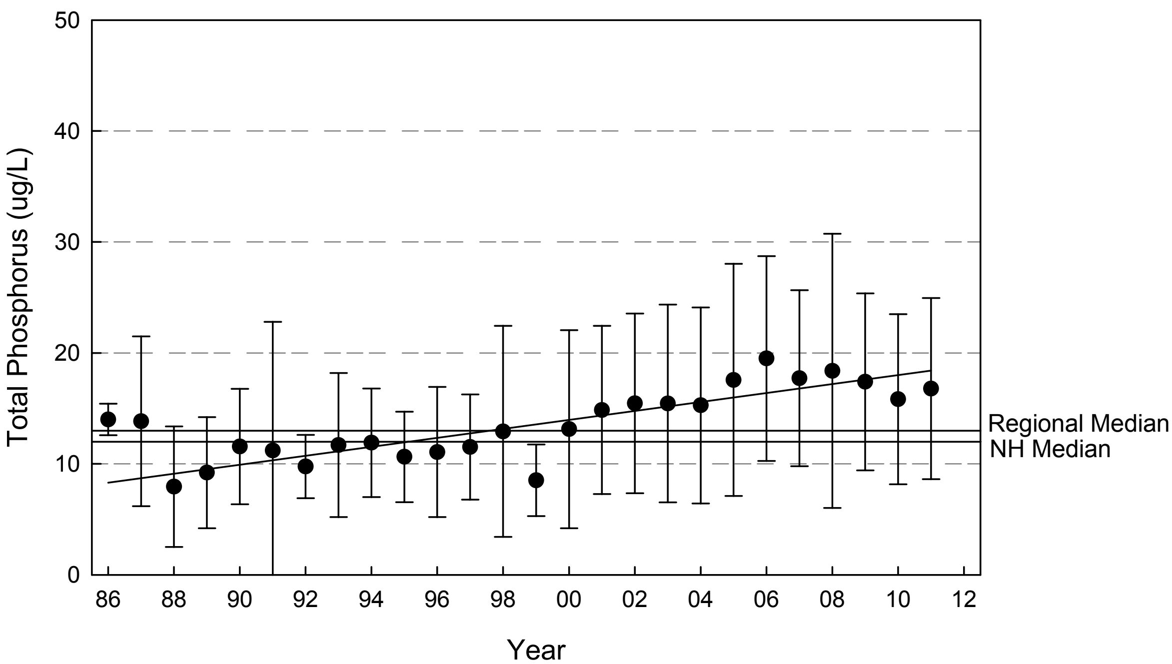


Figure 10 represents the average annual epilimnetic phosphorus concentration for the MV region. The average annual epilimnetic phosphorus concentration remained between 9 and 14 ug/L from 1986 through 1999. In 2000, the Manchester urban ponds joined the program and average regional phosphorus concentrations rose to 15 ug/L. From 2005 through 2011, average regional phosphorus concentrations jumped again to between 16 and 18 ug/L potentially as a result of frequent and large scale rain and flood events during this period. Visual observation of the trend line indicates regional epilimnetic phosphorus concentrations have increased over time.

Figure 10. MV Region Average Annual Epilimnetic Phosphorus Concentration



Epilimnetic Phosphorus Trend Analyses

MV region lakes with 10 or more consecutive years of data were subject to statistical analyses to determine whether water quality trends were significantly improving, degrading, stable, or variable, meaning values fluctuate between years and there is no clear trend. Epilimnetic total phosphorus trends were assessed for approximately 20 deep spots at 18 lakes in the region. Approximately 70 percent of the MV lakes have 10 or more years of consecutive data collection. This allows a more accurate picture of regional water quality trends.

Table 4 represents the MV lake epilimnetic total phosphorus trends with the direction of the arrow indicating whether the phosphorus has increased, decreased, or remained stable. Note that improving trends reflect a decrease in phosphorus levels, and vice-versa. Sixty percent of lake deep spots have a stable epilimnetic phosphorus trend, meaning the phosphorus concentrations have not significantly improved or degraded since monitoring began. No lake deep spots have an improving, or decreasing, epilimnetic phosphorus trend, while 20 percent of lake deep spots have a degrading, or increasing, epilimnetic phosphorus trend.

Increasing epilimnetic phosphorus trends are often a result of phosphorus-enriched stormwater runoff related to increased watershed development. An increase in watershed development often results in an increase in impervious surfaces and unstable sediments. This contributes to an increase in stormwater runoff and sedimentation to rivers and lakes. Efforts should be made to adopt watershed ordinances to limit stormwater runoff and other phosphorus contributions. Watershed residents should be educated on utilizing and installing best management practices to control stormwater runoff from their own properties. For more information and resources to control phosphorus loading refer to Appendix B.

Table 4. Epilimnetic Total Phosphorus Trends in MV Lakes

Lake Name	Improve	Degrade	Stable	Variable
Cobbetts Pond (2 stations)		▲		
Crystal Lake		▲		
Great Pond, North		▲		
Canobie Lake			►◄	
Captains Pond			►◄	
Deering Lake			►◄	
Dorrs Pond			►◄	
Great Pond, South			►◄	
Big Island Pond			►◄	
Nutts Pond			►◄	
Pine Island Pond			►◄	
Pleasant Pond			►◄	
Robinson Pond			►◄	
Rock Pond			►◄	
Scobie Pond (Haunted Lake)			►◄	
Beaver Lake				✶
Pratt Pond				✶
Sebbins Pond				✶
Stevens Pond				✶

Dissolved Oxygen Data Analysis

The presence of dissolved oxygen is vital to bottom-dwelling organisms as well as fish and amphibians. If the concentration of dissolved oxygen is low, typically less than 5 mg/L, species intolerant, meaning sensitive, to this situation, such as trout, will be forced to migrate closer to the surface where there is more dissolved oxygen but the water is generally warmer, and the species may not survive. Temperature and time of day also play a role in the amount of dissolved oxygen in the water column. Water can hold more oxygen at colder temperatures than at warmer temperatures. Therefore, a lake will typically have a higher concentration of dissolved oxygen during the winter, spring, and fall than during the summer. Oxygen concentrations are typically lower overnight than during the day. Plants and algae respire (use oxygen) at night and photosynthesize (produce oxygen) during the day. Dissolved oxygen levels may shift depending on the abundance of aquatic plants and algae in the littoral (near shore) and pelagic (deep water) zones.

Dissolved oxygen and temperature profiles are collected at VLAP lakes on an annual or bi-annual basis. The average dissolved oxygen levels for the MV region is 5.19 mg/L, which is in the critical range for aquatic life support. For additional information regarding dissolved oxygen please refer to Appendix A.

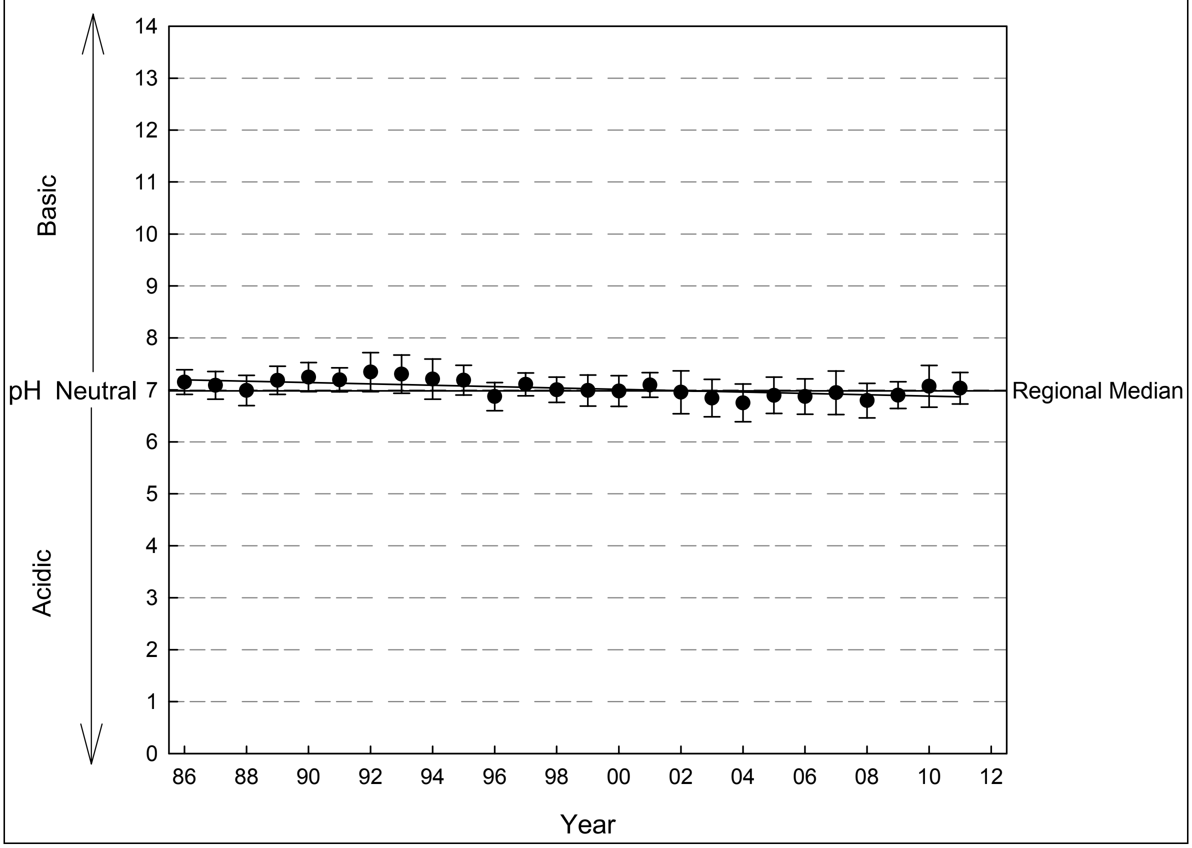
Annual and Historical Deep Spot pH Data Analysis

pH is measured on a logarithmic scale of 0 (acidic) to 14 (basic). pH is important to the survival and reproduction of fish and other aquatic life. A pH below 6.0 typically limits the growth and reproduction of fish. A waterbody is considered impaired for aquatic life when the pH falls below 6.5 or above 8.0. **The median epilimnetic pH for New Hampshire's lakes is 6.6, which indicates that the state surface waters are slightly acidic. The median epilimnetic pH for the MV region is 6.98.**

Figure 11 represents the average annual pH value for MV lakes compared with the regional median. The 2011 average epilimnetic pH value at MV lakes was 7.03, which means that the water is *approximately neutral*. The lowest, most acidic, average pH value was 6.05 measured at Pratt Pond in New Ipswich whereas; the highest, most basic, pH value was 7.55 measured at Cobbetts Pond in Windham. Although a large fluctuation is not noticeable, visual inspection of the trend line indicates pH is becoming slightly more acidic.

Variations in pH values between lakes and between different geographical regions may depend on the composition and weathering of underlying bedrock and the lake water chemistry. Another contributing factor to pH is acid deposition received as a result of emissions from power plants and vehicles. This increases levels of atmospheric carbon, nitrogen and sulfur which fall back to the earth in the form of acidic precipitation.

Figure 11. MV Region Average Annual Epilimnetic pH

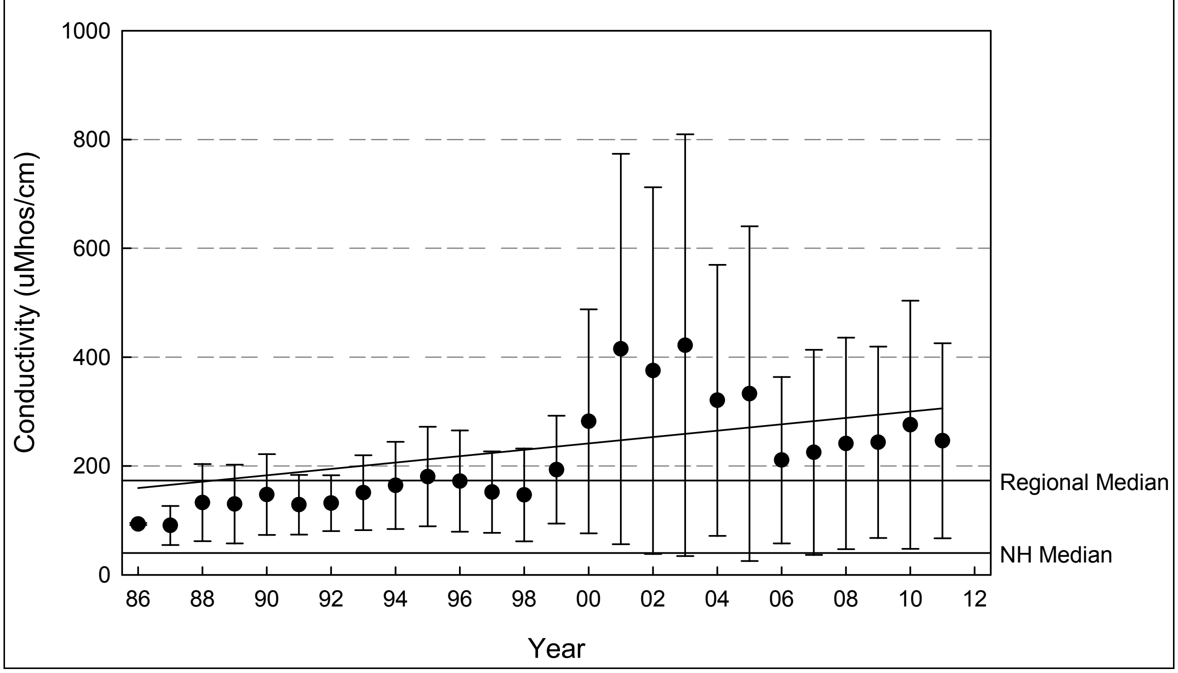


Annual and Historical Deep Spot Conductivity and Chloride Data Analysis

Conductivity is the numerical expression of the ability of water to carry an electric current, which is determined by the number of negatively charged ions from metals, salts, and minerals in the water column. The soft waters of New Hampshire have traditionally low conductivity values, generally less than 50 uMhos/cm. However, specific categories of good and bad levels cannot be constructed for conductivity because variations in watershed geology can result in natural fluctuations. **The median conductivity value for New Hampshire's lakes and ponds is 40.0 uMhos/cm. The median epilimnetic conductivity value for the MV region is 173.0 uMhos/cm.**

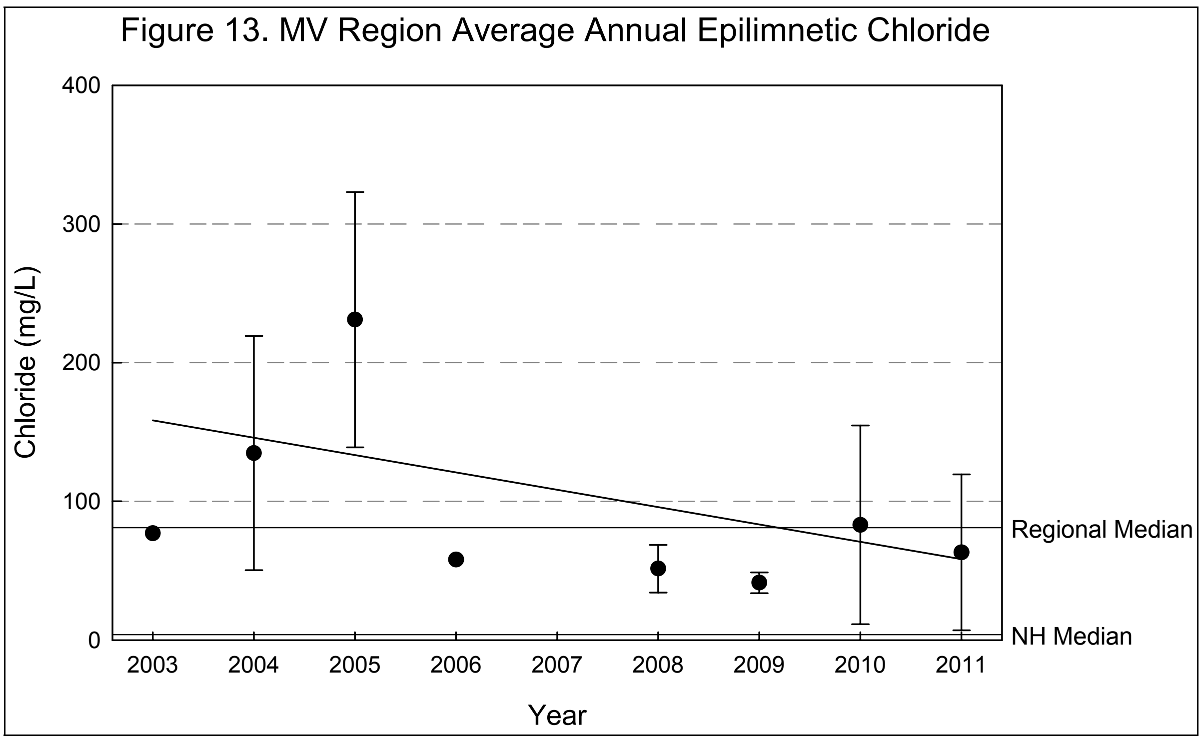
Figure 12 represents the 2011 average epilimnetic conductivity value at MV lakes compared with regional and state medians. Conductivity values fluctuate widely among the region's lakes. The lowest average conductivity value of 15.9 uMhos/cm was measured at Pratt Pond in New Ipswich whereas the highest average value of 705.3 uMhos/cm was measured at Stevens Pond in Manchester. A wide range of watershed types and degrees of development exists in the region. Pratt Pond's watershed has minor development when compared to Stevens Pond in Manchester which abuts I-93 and receives stormwater runoff from the highway. Prior to the Manchester Urban Ponds joining VLAP in 2000, the average regional conductivity was between 100.0 and 150.0 uMhos/cm, but jumped greatly with the addition of the urban ponds. These ponds receive a large amount of stormwater runoff from impervious surfaces which has resulted in extremely elevated conductivities. Implementing stormwater best management practices around the urban ponds has resulted in lowering conductivity levels and is reflected in the lower annual averages measured since 2006.

Figure 12. MV Region Average Annual Epilimnetic Conductivity



Generally, conductivity values in New Hampshire lakes exceeding **100 uMhos/cm** indicate cultural, meaning human, disturbances. An elevated conductivity trend typically indicates point source and/or non-point sources of pollution are occurring within the watershed. These sources include failed or marginally functioning septic systems, agricultural runoff, and road runoff, and groundwater inputs. New development in the watershed can alter runoff patterns and expose new soil and bedrock areas, which could also contribute to increasing conductivity. In addition, natural sources, such as mineral deposits in bedrock, can influence conductivity.

The chloride ion (Cl^-) is found naturally in some surface and ground waters and in high concentrations in seawater. Research has shown that elevated chloride levels can be toxic to freshwater aquatic life. In order to protect freshwater aquatic life in New Hampshire, the state has adopted **acute and chronic** chloride criteria of **860 and 230 mg/L** respectively. The chloride content in New Hampshire lakes is naturally low in surface waters located in remote areas away from habitation. Higher values are generally associated with salted highways and, to a lesser extent, with septic inputs. **The median chloride value for New Hampshire's lakes is 4 mg/L. The median epilimnetic chloride value for the MV region is 81 mg/L.**



Regional conductivity is impacted by de-icing materials applied to driveways, roadways and in particular I-93. Figure 13 depicts average annual epilimnetic chloride levels for select regional lakes. The chloride measurement is relatively new for VLAP and is an optional analyte for participating lakes. Lakes that serve as water supplies or where conductivity levels may be influenced by chloride are analyzed annually. For the MV region, chloride levels were analyzed mainly on the Manchester Urban Ponds prior to 2008. From 2008 through 2011, the majority of regional lakes were analyzed for chloride. Chloride levels in the Manchester Urban Ponds frequently exceed the chronic chloride criteria of 230 mg/L. However, the remaining regional lakes experience chloride levels that are less than the acute and chronic chloride criteria; however, they are much greater than what we would typically measure in undisturbed NH surface waters.

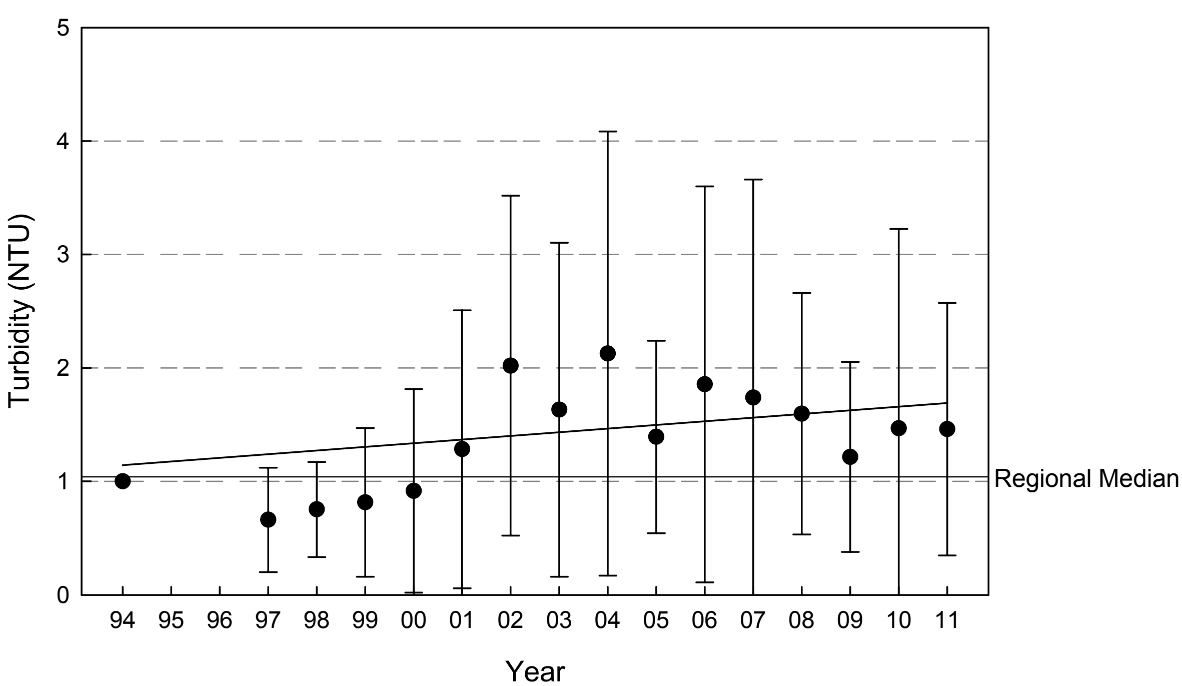
Watershed management efforts to control un-natural sources of conductivity and chloride in waterbodies should employ a combination of best management practices in regards to winter salting practices. State and local governments and private homeowners should evaluate the use of road salt and alternatives to reduce the amount of material applied while maintaining public safety. *For additional information on the relationship between conductivity and chloride, please refer to Appendix A. For additional information on best management practices please refer to Appendix B.*

Annual and Historical Deep Spot Turbidity Data Analysis

Turbidity in the water is caused by suspended matter (such as clay, silt, and algae) that cause light to be scattered and absorbed, not transmitted in straight lines through water. Water clarity is strongly influenced by turbidity. **The Class B surface water quality standard for turbidity is no greater than 10 NTUs over the lake background level. The median epilimnetic turbidity for the MV region is 1.04 NTU.**

Figure 14 represents the average annual epilimnetic turbidity for the MV region. The 2011 average epilimnetic turbidity at MV lakes was 1.46 NTU, which is slightly greater than the regional median. Regional epilimnetic turbidity is typically between 1.0 and 2.0 NTU and is above average for most NH lakes. The trend line indicates average annual turbidity levels have increased slightly, however it appears they have remained relatively stable since 2005. New Hampshire has experienced more significant rainfall events in recent years which may be contributing to an increase in stormwater runoff and turbidity in the region's lakes.

Figure 14. MV Region Average Annual Epilimnetic Turbidity



Elevated deep spot turbidity levels are typically the result of stormwater runoff, algal or cyanobacteria blooms, and/or disturbance of lake bottom sediments. Stormwater BMPs should be implemented when possible to reduce the amount of suspended sediments and debris transported to surface water. Boating activity in shallow areas should adhere to rules specified by the NH Marine Patrol in regards to speed and no wake zones. If an algal or cyanobacteria bloom is observed, please contact DES immediately. *For additional information on stormwater BMPs, boating, algae, and cyanobacteria please refer to Appendices A and B.*

Reference:

Gibbs, J. P., Halstead, J. M., Boyle, K. J., & Huang, J. (2002). An hedonic analysis of the effects of lake water clarity on new hampshire lakefront properties. *Agricultural and Resource Economics Review*, *31*(1), 39-46.

Loder, A. (2011, September 08). *Vacation communities and the rest of new hampshire: How their tax rates compare*. Retrieved from http://stateimpact.npr.org/new-hampshire 2/27/2012

Nordstrom, A. The New Hampshire Lakes, Rivers, Streams and Ponds Partnership, (2007). *The economic impact of potential decline in new hampshire water quality: The link between visitor perceptions, usage and spending*

Sundquist, D. Society for the Protection of New Hampshire Forests, (2010). *New hampshire's changing landscape 2010*

The Society for the Protection of New Hampshire Forests, (1999). *The economic impact of open space in new hampshire*